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ABSTRACT

The integrated information system element of the management information system concept has practical applications for management in the areas of both information analysis and decision-model building. Four basic options for achieving integration in operational data systems are: a default option, the coordinated file option, the distributed processing option, and the data base option. Arizona State University (ASU) has chosen a data base management system (DBMS) to coordinate disparate existing systems and eliminate extensive manual integration of data from the various systems. However, raising a budget for the project is not a simple matter. Difficulties also arise in convincing the diverse elements of a university's bureaucratic hierarchy to cooperate on a DBMS. At ASU, a Data Base Review Committee, representing major administrative areas, has been set up to encourage effective management/technical interaction and inter-departmental cooperation in data base development. (Author/LS)

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MANAGEMENT/TECHNICAL INTERACTION IN INTEGRATED INFORMATION SYSTEM DEVELOPMENT

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MANAGEMENT/TECHNICAL INTERACTION

IN INTEGRATED INFORMATION SYSTEM DEVELOPMENT

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The "Integrated System Approach"

"State of the art" computer-based information system development has come a long way toward realizing the theoretical potential described in the Management Information System (MIS) literature of the mid-sixties. Four or five years ago, the MIS movement appeared to have lost much of its "buzz-word" popularity -- which was reflected in the number of articles describing "MIS-failures" and "costly disappointments" in business and industry. Currently, however, there seems to be a growing number of reports of successful MIS implementations (complete with sophisticated built-in decision model capabilities) and a growing body of evidence that the MIS concept is "here to stay."

One of the elements of the MIS movement that is acquiring increased practical credibility is the concept of the "integrated information system." Admittedly, the ideal of the "totally integrated" system remains just that -- an ideal, but the concept appears to be gaining new adherents, and expanded theoretical possibilities. For example, Sprague and Watson[1] recently proposed a conceptual framework for a business "decision support system" which proposes integration of: all relevant internal and external data collection, manipulation and analysis; all management decision-model building activities; the resulting decision models themselves (at three different "levels"); and, through the use of a high-level command language, the decision/maker user

(see Figure 1). This represents a challenge for attempting a very high level of integration indeed, and one might well ask how it might be realistically accomplished, particularly in a college or university.

The need for skilled decision-model builders aside, the basic requirement for successful application of the concepts proposed in the Sprague/Watson model is achieving effective integration of the operational systems(where "transaction data" are captured, stored and processed) so that a viable "decision support data base" can be constructed. As indicated in Figure 1, in a typical business, the four basic transaction data systems are production, marketing, finance and personnel; substitute "student" and "facilities" information systems for production and marketing, and the model applies just as well to a college or university.

What are the alternatives for achieving integration in operational data systems? At a broad conceptual level, there appears to be four basic options (these will almost certainly overlap in actual practice): (1) a default option, (2) the "coordinated file" option, (3) the "distributed processing" option, and (4) the "data base" option.

The obvious "default option" is depicted in Figure 2. This is the situation where little or no integration exists between operational data systems so that the only means that exists for correlating data from different departments is "manual massage." Practical experience from an administration point of view affirms that manual massage is "alive and well" and, to some degree, will undoubtedly live on forever. For example, the Office of Institutional Studies at Arizona State University (ASU) is currently faced with the prospect of considerable manual effort in bringing together faculty data (for cost analysis purposes) that are presently scattered among four basic systems: Position Control, the Academic Vice President's Faculty File, the Payroll Master File, and the Master Course File. It is almost impossible

to describe to some university administrators the amount of manual effort that is sometimes required to pull together accurate, timely data from four separate systems which were each designed with a distinct purpose in mind.

Of course, the basic option for achieving integration in the data processing shop is the technique of "coordinated file processing" (see Figure 3). Here, integration is accomplished through "cross-walk programming," the creation of "extract files" of selected data elements from operational systems, and other similar techniques. For example, as a possible interim solution to the ASU faculty data problem mentioned above, Administrative Systems and Programming personnel -- without changing the basic operational systems in any way -- may develop the necessary software to create and maintain a new "personnel history file" which extracts data from all four operational systems. Unfortunately, data processing technicians are well aware of the complexities and problems associated with this type of procedure -- especially where standardized assumptions and basic data element definitions are lacking. Data Management System software (not to be confused with Data Base Management Systems, to be discussed later) such as Informatics' MARK IV, can go a long way toward facilitating correlation of data in a basically non-integrated environment; however, standard "keys" for cross-referencing data must be present in the existing files, or added later -- perhaps at considerable expense. Because this method of achieving system integration is necessarily "after the fact," there will almost always be deficiencies of one type or another in the results.

A new bandwagon which offers an option for integrating with a somewhat different twist is "distributed processing." The development of economical intelligent terminals, compatible mini-computer systems, key-to-disk hardware, and specialized "turn-key" systems has already had substantial impact

on traditional systems design concepts. For example, a centralized keypunch operation was once the "rule" for data entry at ASU. Today, keypunch machines have been replaced with UNIVAC key-to-disk equipment, including "distributed" key stations for direct input of transactions in the university purchasing department. Also, new equipment has been purchased for university cashiers which includes a built-in minicomputer (and random access storage) that will interface with the main financial system at the central site. The implication is clear that, as distributed processing concepts become widespread, a new level of "hardware dependent" integration will be designed into specialized subsystems that "talk to" or "feed" one another at different levels of interaction (see Figure 4).

The final option, and the one selected at ASU as the primary method of achieving "truly" integrated data processing on our campus, is the development of an integrated data base through the use of a Data Base Management System (DBMS). In our case, the DBMS software being used is UNIVAC's DMS-1100; other commercially available DBMS packages include TOTAL, IDMS, SYSTEM 2000, ADABAS and IMS2 (for IBM users). Essentially, a DBMS package facilitates non-redundant, application-independent data storage with data elements linked together in a variety of possible hierarchical or network (chained) relationships. To oversimplify, instead of data inputs from different functional areas within the university being fed into physically separate tape and disk files, selected inputs from the various departments are funneled through carefully controlled maintenance procedures into a single mass storage "file" (see Figure 5). Theoretically, at least, the data elements stored in the resulting data base may be linked in an infinite variety of ways to produce required reports.

The expected advantages and potential benefits which prompted the selection of the DBMS approach at Arizona State University have been presented elsewhere.[2]

Perhaps the major disadvantage of the approach is that it represents not only a technological departure from traditional data processing methods, but a conceptual and philosophical departure as well. From a systems analyst point of view, this conceptual difference has been expressed by one author as follows:

> "The traditional approach to data processing development has been the specification of a problem followed by its design, implementation and delivery to the user. This methodology implies that the problem derives programs, and that the programs derive the files on which the programs will operate. That is, the files of the traditional function or file oriented approach to data processing are intimately connected to the programs that operate on them.
>
> . . . rather than beginning with a design and implementation for a particular problem, data base asks that we develop first the data necessary to the solution of the problem. That is, instead of developing algorithms, and implementing programs to represent them, we must first bring together all of the data that is necessary for provision of the services that will be delivered by the execution of the new application system on the data base."[3]

From a management point of view (and the rest of the user community) the primary conceptual difficulty seems to be one of convincing people of the potentially over-riding benefits to be realized from maintaining the data base as a "shared resource." Simply put, user departments must be convinced that they will benefit from replacement of their "cherished" (proprietary) file-oriented systems with a single data base system that can be "shared" by the community of users.

History and Organization of the University: Some Implications

The organization of the typical university, historically and operationally, dictates against the DBMS approach. With its increasing complexity of operations the university has taken its place as a valid bureaucracy (many in the over 100 million dollar class) with a very distinct hierarchy of department heads, directors and vice presidents. This bureaucracy fragments data processing systems and

works against the concept of a unified approach to information handling. One of the reasons for this fragmentation has been a clear lack of understanding by the administration as to the complexity of data gathering and its validity in university operations. This lack of understanding, coupled with the propensity of academia to eschew any form of cost analysis, has led to an organizational dichotomy when academia has hired a set of "experts" to "handle the business and run the shop." The university has suffered because report producing activities have been polarized away from the academic program, but have become absolutely necessary to its operation and objectives.

Experience has shown that each office or administrative unit within the university develops its own "file system" complete from data collection forms to Hollerith cards, to computer tape and disk files. Only a minority of these are designed to satisfy needs outside the originating office. Duplication becomes the style leader and standardization is highly fragmented or ignored. The status quo is encouraged by ill-defined data elements, "sloppy" data files, and a perception that planning ends at the office door. Introduced into this maze of self-interests, with its provincial and petty procedures, the DBMS approach presents a distinct educational and learning problem to the university community.

In most cases, the educational process required for implementation of a DBMS will need to be "forced" because there is very little liklihood that a cooperative endeavor will evolve without a strong outside stimulus and a predisposition to respond to such a stimulus. The university community is not known for effective self-study of its own operations.

The establishment of an integrated data base is like many other "innovations" which may rise to certain heights of administrative dominance. Acceptance of the DBMS approach will depend on (1) a pressing need (or at least a need that

is perceived as pressing), (2) the tacit support of key top mangement, (3) adequate or more than adequate budget and personnel or, lacking that, some type of "pirated" support, and (4) an entrenched operational mode. In these days of budget restrictions and possible cutbacks, the outlook for potentially expensive new approaches has been reduced -- yet the same monetary restrictions may force an evaluation of alternative methods.

Proponents of institutional research, learning resource laboratories, the "university without walls" concept, and MIS have all used, with varying degrees of success, the procedures outlined above. The business and financial departments of the university used such procedures thirty years ago to firmly entrench themselves. Their celebrated cause was "financial accounting by the state," an imposed bureaucratic inconvenience that academia quickly turned over to business "professionals." To the extent that the four conditions are met, the DBMS will be successful. We may ask, what are the chances? Is it possible to introduce a drastically different set of standards into a well-entrenched bureaucracy?

Most often the university reacts only to what has been called "macro-environment press"; that is, to the <u>demands</u> of those outside agencies which require data or information. The state or federal agency that makes the request is perceived as important depending upon the "power over the budget" held by that agency. Correlated with the perceived outside need is the local perception of vested interests; that is, the old admonition of "let us hand together or we will hang separately," a prevailing concept among many vice-presidents.

Basic then to DBMS is a need, either real or perceived, which has been assigned to or recognized by top management. Top management itself will

contain very few people capable of or willing to direct implementation of the DBMS approach. The "grab for power" will be perceived as exactly that -- with a rationale for the common good of the university running a poor second. Looking at the university as a single, comprehensive entity is not a common outlook for top management.

Simply put, top management is either "too busy" or not sufficiently technically oriented to guide DBMS implementation. Their task is to perceive in a political reality what they do best -- service the demands for information about what is going on at the university while keeping the till full and money flowing. Top management's position is not really to accentuate the truth, but to maintain that which is defensible and that which allows the opponent little opportunity to know exactly what is happening. The charisma of a president was, and is, indeed a powerful factor in selling higher education. Boards, legislative groups and NCHEMS are applying pressures that are changing the role of the president and the "higher education" he must now "sell" is changing continually to fit different standards. Data and information are "getting into the game" and top management can no longer depend upon the ability of any single person (no matter how prominent) to sell the story. "Evaluation" is no longer accomplished in a day testifying before the legislature, but now is year long and in excruciating detail. The demands are here and becoming stronger each year. Those who wait until that last minute to start their integrated information system will find themselves at a severe disadvantage in the information game.

Budgetary and Organizational Impacts

The impact of a DBMS approach may be likened to the impact of computer systems in general, when assessed for potential budget and organizational change.

An integrated data base is potentially expensive, and budget conscious administrators may not appreciate the financial drain that might occur. However, the alternative is also costly -- a lack of information. Worse, in a large university, the intangible drain on personnel and their time is almost incalculable where extensive, unnecessary clerical tasks are required to integrate information from existing systems. Furthermore, many administrators would rather incur the expense of hiring a larger office staff than cooperate in efforts directed toward creating more efficient integrated systems. Unfortunately, power and authority are derived from the larger staff and the quantity of routine procedures performed.

Granted, the scope of administrative responsibility has increased during the past ten years. Budgets, Affirmative Action, EEO and "sponsored research" have individually created their own problems of increased work load; however, the principal problem is that they have grown in piecemeal fashion, again reflecting the organizational history of the university! Simply stated, impact on the institutional budget will most probably be acknowledged in typical academic fashion; that is, the new approach to information processing must compete against the established bureaucracy for necessary resources. "All new programs must compete against operational sacred cows," is another way of stating this problem that DBMS implementers must face.

An operational DBMS may only achieve functional power as a result of budgetary attacks on the university and the need to provide integrated information to meet those attacks. Organizationally, the establishment of the integrated data base will be dictated at the highest level as a function of power and authority. Clearly, the vice presidents (normally in direct competition with one another) should champion DBMS. Organizationally, one of these political identities -- or the president himself -- must carry the fight.

Yet the most important planning and operational activities lie with middle management. This group will have the necessary knowledge -- in sufficient detail -- to validate the DBMS-based system. While they lack the influence of "single coordination" (a reasonable disadvantage when working with the various offices and units on campus) there is no other group with the knowledge and time to provide adequate support for the DBMS effort. After the need for information is perceived and top management provides for its establishment, the actual job lies with middle management.

We might then ask, what might motivate the middle management group in a specific university environment to assume the responsibilities associated with DBMS implementation? Technically, the hardware and software are available. The real crux of the problem lies in the conflict of DBMS-based integration with the traditional university -- its provincial, archaic approaches, sheer inertia, and hidden confusions can only be overcome in the power struggle through middle management support. Proponents of the integrated system must be in tune with the "bureaucratic concerns" of middle managers and successfully demonstrate how the data base can help alleviate those concerns. At any rate, there is no other viable resource -- top management has generally failed (with some exceptions) to show the necessary leadership in this area.

In view of the above, steps toward integrated data base implementation will probably involve middle management pushing top management for acceptance. The perception of those in middle management and their education will play an important part in the DBMS effort. Assuming a need is recognized by top management, and is eventually expressed in a policy of action, there are several other problems to be overcome. One is that of providing an "administrative vehicle" for successful planning and implementation. Unfortunately, in a large university there are many persons who are apparent "strangers

to each other" in middle management -- aware only fleetingly of the responsibilities of others. Even those having a clear concept of what they need and have, can be totally ignorant of the complexity and inter-departmental implications of an integrated system effort.

Another requirement is that a designated team of experts with a clearly specific chairman or leader should be appointed to help with DBMS implementation. These may or may not be from middle management, but would necessarily include systems personnel. The critical educational problem here surrounds the principle of "involvement." Educational methods should be based on the concept that there is a single "whole" which is greater than the "parts." While there may need to be an administrative "Czar" to determine policy and "who is going to do what," the essential concept must be established that a DBMS-based integrated system is a university concept and not charged to any single office or department.

The "Data Base Review Committee" Concept: Background

Generally, in traditional "file-oriented" system development, the systems analyst can focus almost all of his design efforts toward satisfying the needs of a "single department" client/user. In contrast, in a DBMS-based integrared environment, while a project leader may still be working toward the goal of satisfying a particular user-department, his efforts will be much more constrained by "total system" requirements.

What this means in terms of technical interaction, is that the analyst/project leader must now interface with a new element within his own shop, i.e., the data base administrator and other members of the "data base support group." In terms of management/tehcnical interaction, no longer can the analyst content himself that the requirements for a good system design will be met if the primary user department head "approves." That department head (whether it be the Registrar, Comptroller, Director of Financial Aids, etc.) will no longer be responsible for a data processing system that functions essentially in

isolation from all other systems on campus, but will "manage" a component subsystem of the larger, integrated framework. Therefore, the analyst/project leader must be much more aware of the data processing requirements of the "managers" (department heads, deans, etc.) in other areas -- and how they relate to his project -- than has traditionally been the case.

Some persons will argue that good systems analysts have always considered interpersonal interaction outside of the narrow confines of their specific "client department," a necessary prerequisite to creating a "good" system design. Also, they will argue that university department heads and directors must necessarily view their area of responsibility as just another component of the larger college or university system. In theory, and in certain specific circumstances, this has undoubtedly been true. Judging from personal experience and the comments of professional collegues, a much more typical situation is where functional departments exist as "little empires" in continual competition for budget dollars via the politics of "good turfmanship." Unfortunately, if this is the case, there will be little motivation for creating efficient integrated data processing systems -- so the proliferation of proprietary "file-oriented" systems continues. On the other hand, in the DBMS-based integrated system environment, inter-departmental interaction is a critical requirement for success; once this fact is recognized and accepted, it can become a primary motivating force in and of itself.

Today it is becoming more and more the case that management information requirements of the central administration (whether at the vice-presidential, presidential, chancellor, or state-wide level) demand effective integration of operational data systems. If the DBMS-approach to integration has been selected, what type of mechanisms might be created to insure that the necessary management/technical interaction and inter-departmental cooperation will occur? One approach is the creation of a top-level data base steering committee with

real authority to direct and control system development within the framework of the integrated approach. In business applications a common recommendation is that the data base administrator have absolute authority on matters concerning the data base, e.g., data element definitions, approval of system designs in all areas of interface, etc. Another approach is to involve representatives of all departments in development of a total system design before implementation of any particular subsystem can begin. One or another of these mechanisms may be the primary ingredient of an approach that incorporates all three; certainly other techniques may be more particularly suited to specific situations and circumstances.

At Arizona State University, conditions have not been favorable to the organization of a powerful "data base steering committee." Furthermore, the role of the "data base administrator" has been conceptualized more as one of technical design and control, as opposed to policy-oriented decision making. The concept of true "total system design" was rejected as too costly, and self-defeating in the long run because of the ever-changing nature of the data processing requirements of the various university departments. A word of explanation is in order on this last point because some type of over-all framework or design structure must be developed to guide data base development. However, a theoretical "schema" of a data base for the university can be developed without excessive cost, which still should be adequate to establish the parameters needed to guide project implementation.

Data Base Review Committee: Organization and Structure

The principal mechanism selected to encourage effective management/technical interaction and inter-departmental cooperation in data base development at ASU has been a twelve-man "Data Base Review Committee" (DBRC). The DBRC is comprised of representatives from the major administrative areas of the university (both central administration and the academic colleges).

-Individuals were selected with a "functional awareness" of university information needs at various levels and for various purposes. The original roster included the following: the Director of Admissions; Assistant Director of Institutional Studies; an Assistant Comptroller; the Director of Payroll; Administrative Assistants to the Deans of the Colleges of Engineering, Business, Liberal Arts, and Graduate College; the Assistant Dean of the College of Fine Arts; Assistant Director of Financial Aids; Assistant Director of Personnel; and, the Assistant Registrar. Ex-officio members include the Coordinator of Information Systems (Chairman), the Director of Administrative Systems and Programming, and the Director of Computing Systems and Operations.

In terms of defined "roles and purposes" the committee is intended as a review board for monitoring the evolution of the data base, and as an "appeals" mechanism for arbitrating disputes that arise in the development of the university integrated system. The DBRC is divided into four "working sub-committees": (1) Data Element Dictionary/Data Definition Sub-Committee, (2) Input/Output Constraints Sub-Committee, (3) Data Base Standards and Controls, and (4) Communications/Interface Sub-Committee. Specific procedures that have been adopted include the following (see Figure 6):

(a) In every project, most of the details of the "System Design" will be worked out by the Project Team as it interacts with users and the Data Base Support Group. However, problems and issues that arise which cannot be resolved by the Project Team or which have implications extending beyond the scope of the project in question, will be forwarded to the appropriate DBRC Sub-Committee through the DBRC chairman.

(b) The DBRC Sub-Committee working on a particular problem will formulate recommendations for presentation to the committee

as a whole.

(c) In most cases, it is hoped that the efforts of the sub-committees will result in recommendations that are, by nature, acceptable to everyone concerned. Where this is not the case, it may be necessary to forward the recommendation to an appropriate "higher authority" in the university administration for resolution.

(d) Since the data element dictionary represents a university resource irrespective of the particular projects under development, ALL proposed additions, changes or deletions must be reviewed by the Data Element Dictionary/Definition Sub-Committee and forwarded (with recommendations) to the Data Base Review Committee. In this way, the capability of the Data Base to satisfy the widely divergent information needs of the university community will be insured.

Thus far, the ASU committee has received briefings from the Coordinator of Information Systems, Data Base Administrator, and the leader of the "Payroll/Position Control" development project. Also, the four sub-committees have met with systems' personnel to discuss potential probelm areas and means for resolution. Members of the DBRC are currently reviewing selected items from the data element dictionary, and have expressed continued interest in the progress of the integrated system effort.

Although it is still too early to determine if the "Data Base Review Committee" concept will be ultimately successful in realizing the goals and purposes outlined above, the initial indication is favorable. If nothing else, there has been a noticeable increase in enthusiasm among university personnel for the integrated system project, and an apparent heightened awareness of the true meaning of "data base." Managers and technicians alike

are coming to realize more and more that DBMS-based integrated system development is something quite different in application than traditional "file-oriented" data processing.

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[2]Don E. Gardner, "Explaining Data Base -- Presenting the Concept to University Administrators" (Proceedings of the 20th Annual College and University Machine Records Conference, May 1-3, 1975, Atlanta, Georgia), pp. 1-18.

[3]Leo J. Cohen, "Data Base Management Systems: The Exterior View," Data Base Newsletter (May 1975), p. 2.

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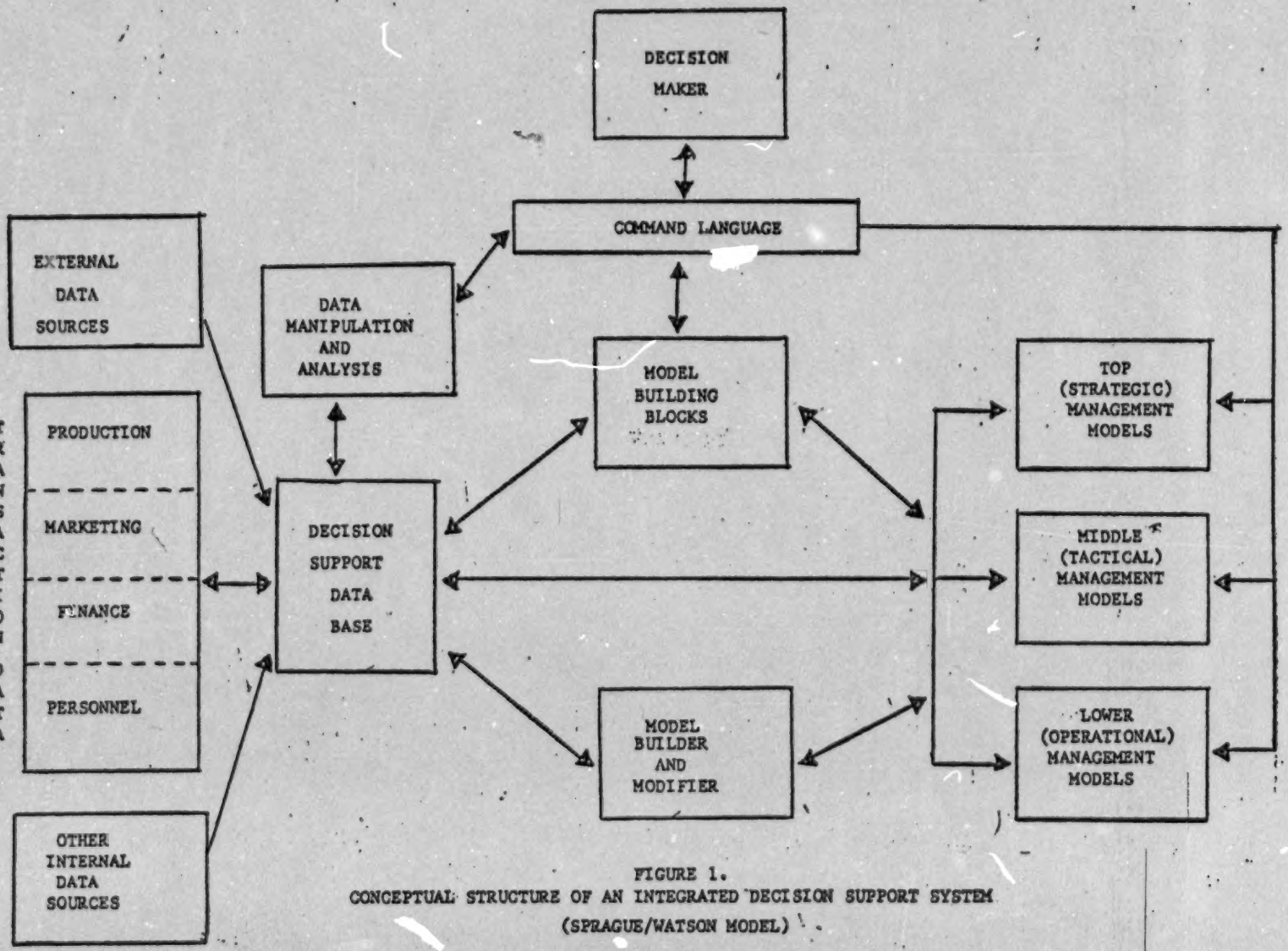

FIGURE 1.
CONCEPTUAL STRUCTURE OF AN INTEGRATED DECISION SUPPORT SYSTEM
(SPRAGUE/WATSON MODEL)

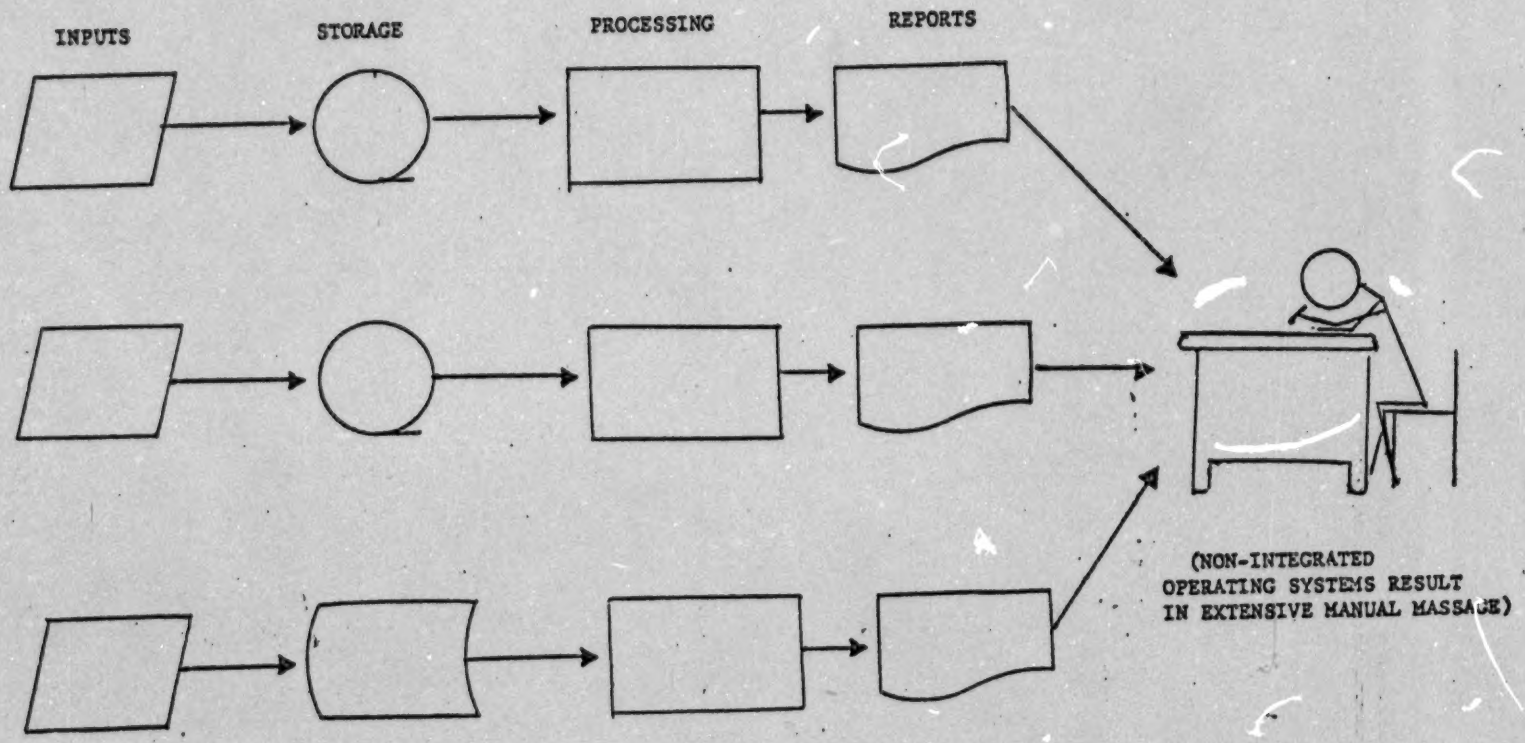

FIGURE 2.

THE "DEFAULT OPTION" FOR ACHIEVING INTEGRATION.

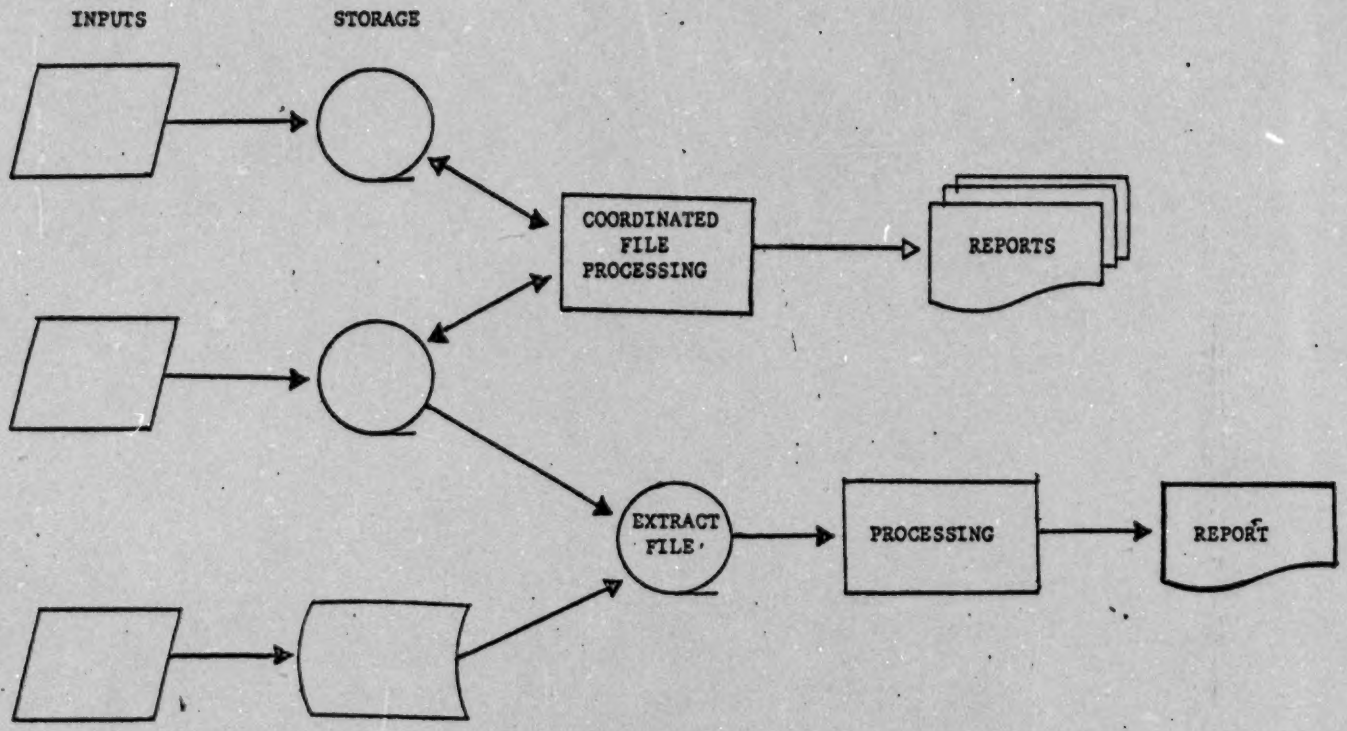

FIGURE 3.

ACHIEVING INTEGRATION THROUGH "COORDINATED FILE" TECHNIQUES

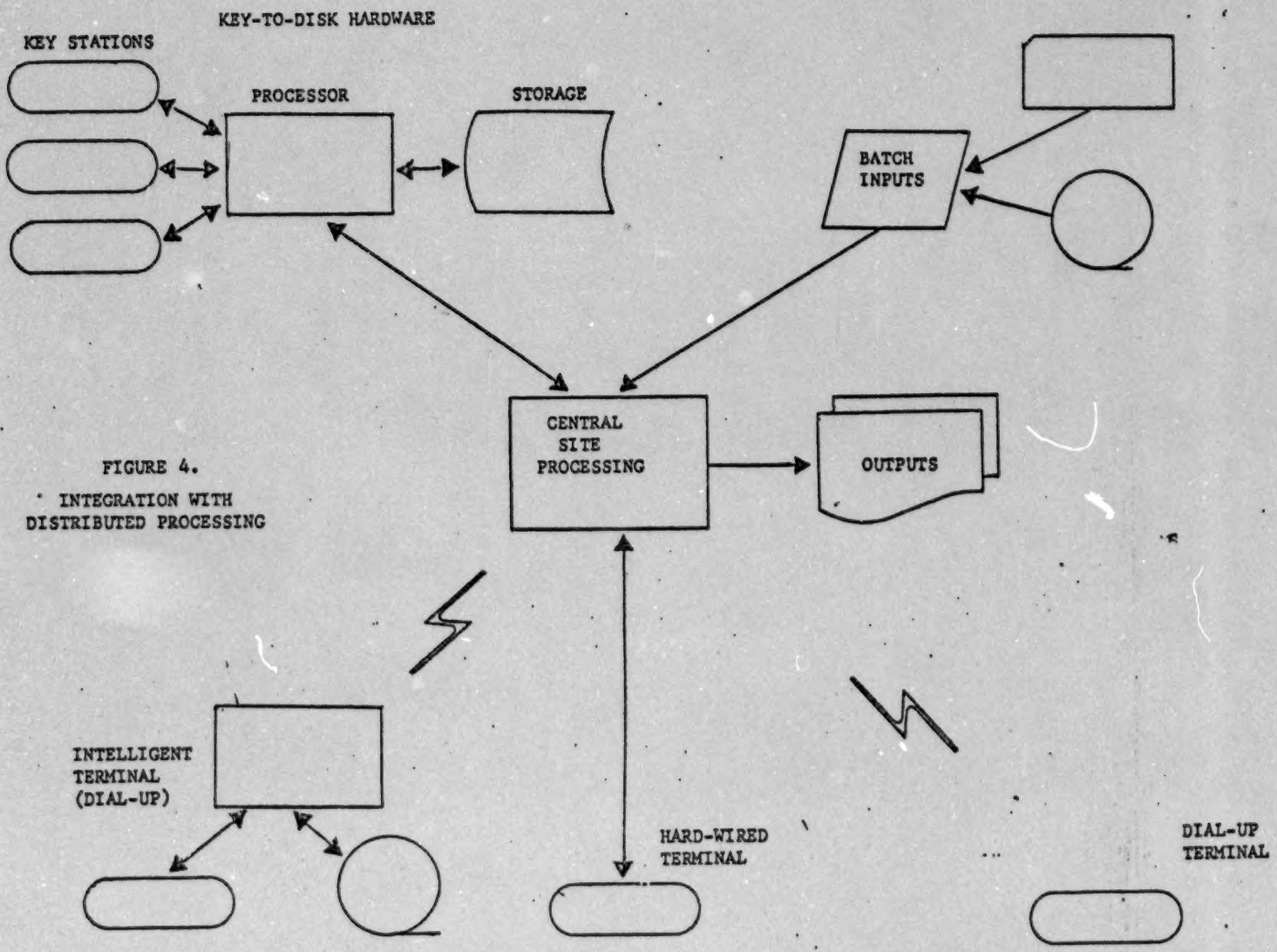

FIGURE 4.

INTEGRATION WITH DISTRIBUTED PROCESSING

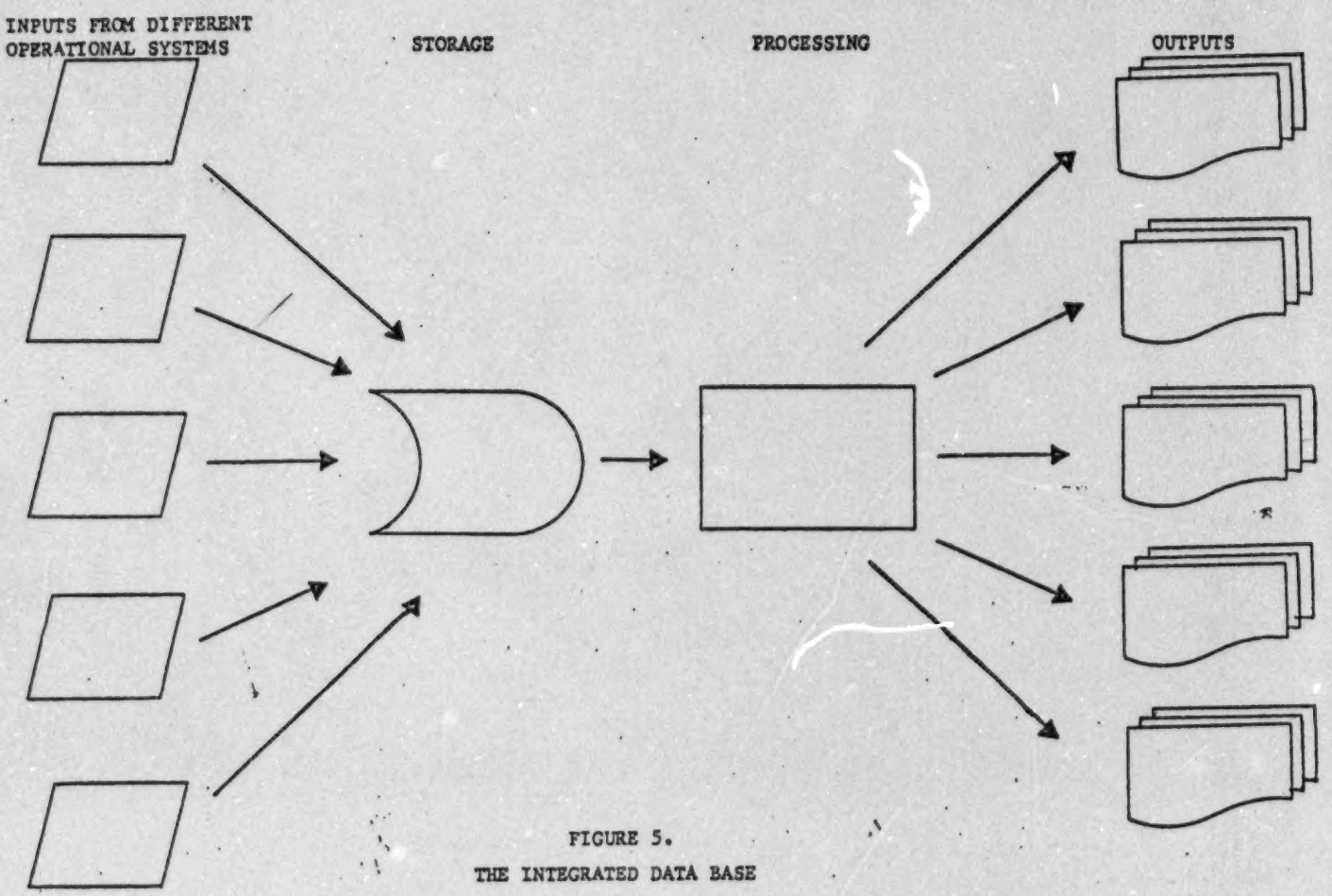

FIGURE 5.
THE INTEGRATED DATA BASE
(DBMS APPROACH)

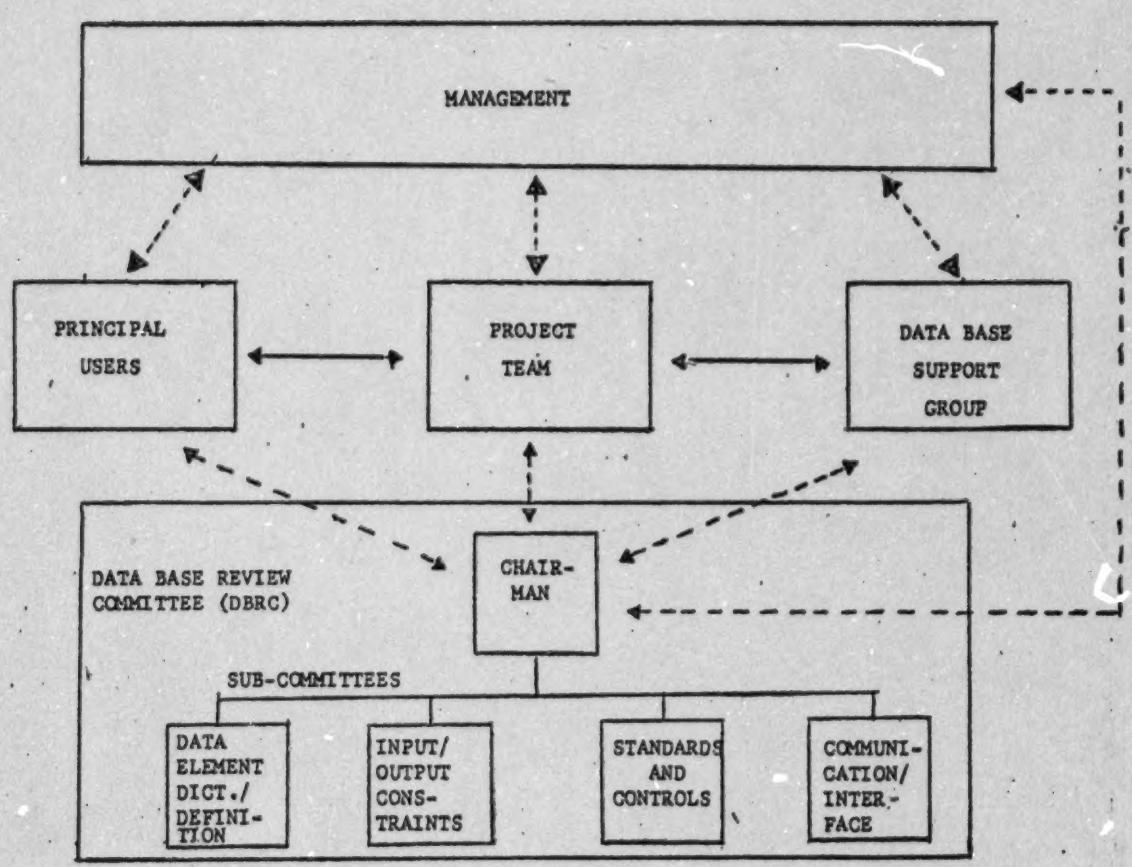

FIGURE 6.

DATA BASE REVIEW COMMITTEE INTERFACE PROCEDURES